

(12) **UK Patent Application** (19) **GB** (11) **2 323 322** (13) **A**

(43) Date of A Publication 23.09.1998

(21) Application No 9805745.8

(22) Date of Filing 19.03.1998

(30) Priority Data

(31) 9705705

(32) 19.03.1997

(33) GB

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(51) INT CL<sup>6</sup>

B29C 45/72 45/14 45/73 45/74 70/06

(52) UK CL (Edition P)

B5A AB11 A1R214D A1R214E A1R214F A1R314C1A  
A1R314C1C A2A1 A2A4X A20T14

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A (TOYOTA) 17.11.89 (see abstract)

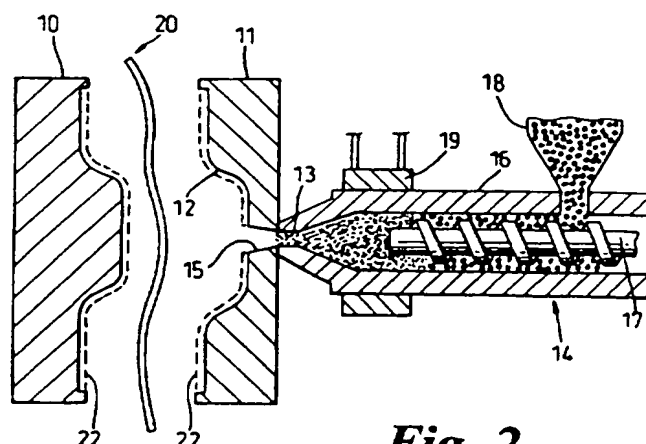
(58) Field of Search

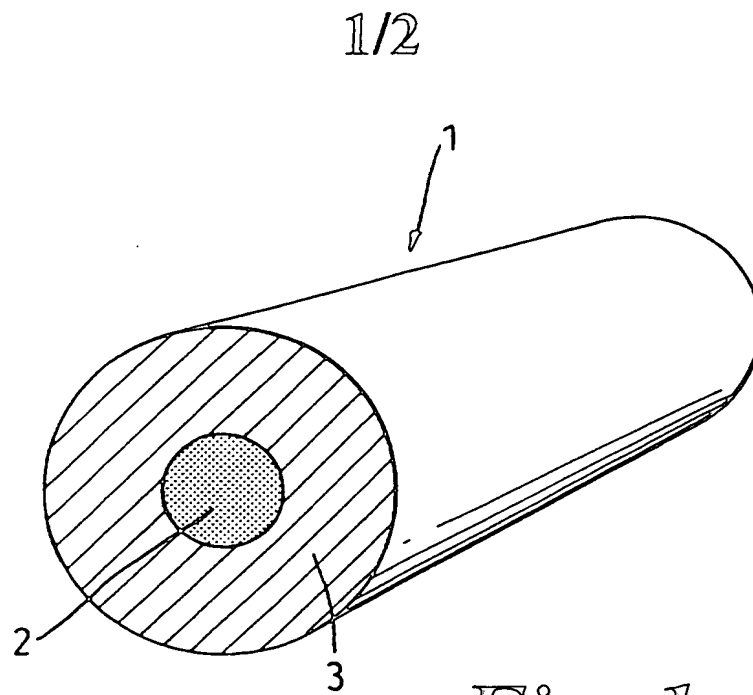
UK CL (Edition P) B5A AA1 AB11 AB14 AD20 AD24P  
AT14M AT14P  
INT CL<sup>6</sup> B29C 45/14 45/72 45/73 45/74 70/06  
Online: WPI

(54) Abstract Title

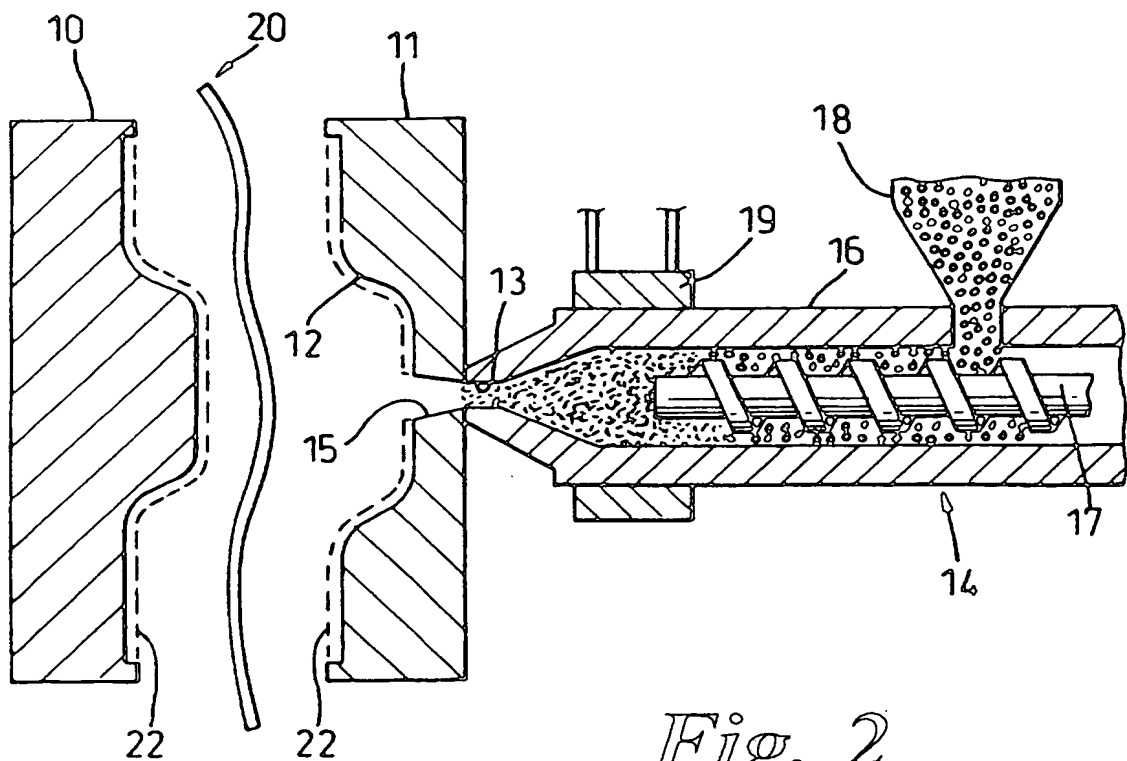
**Fibre reinforced thermoplastics articles**

(57) A fibre reinforced thermoplastic article is formed by providing a cloth (20) incorporating a thermoplastic material and a fibrous material and placing the cloth within a mould (10, 11) of the shape and configuration of the article to be formed. The mould is filled with a molten thermoplastic material from a high pressure injection apparatus (14) which heats and melts the thermoplastic material incorporated in the cloth. The thermoplastic material may be polypropylene and the fibrous material typically comprises glass fibre or mineral wool which is coated with the polypropylene. A pre-painted film (22) of polypropylene may be placed in the mould to produce a painted article with a good finish.

**Fig. 2****GB 2 323 322 A**

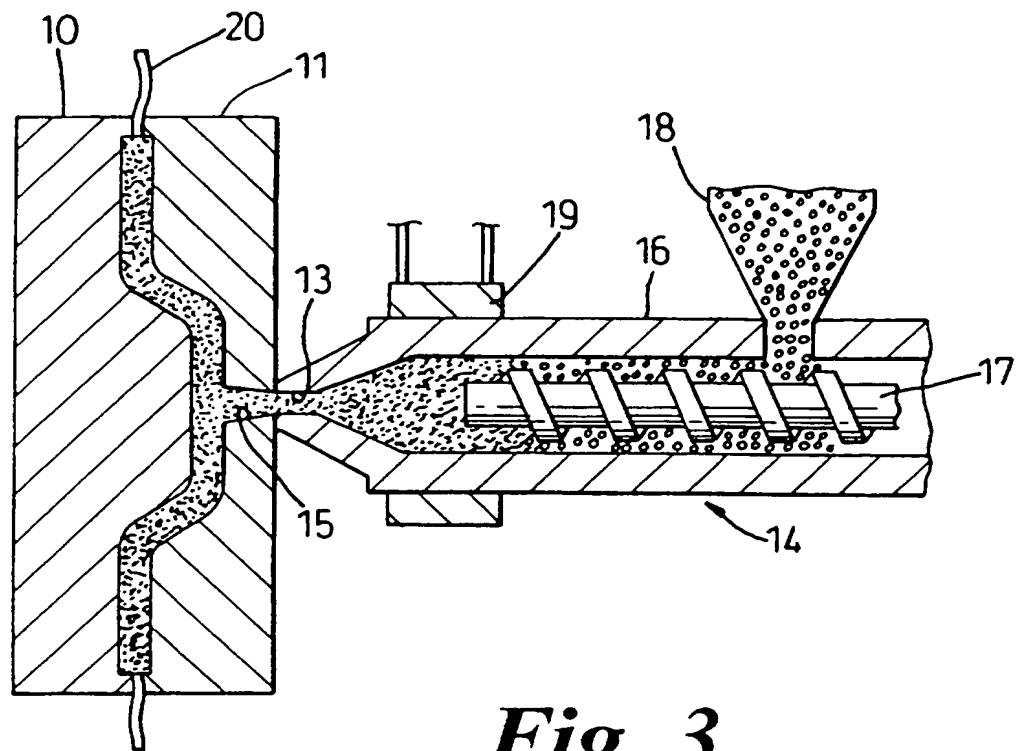


*Fig. 1*

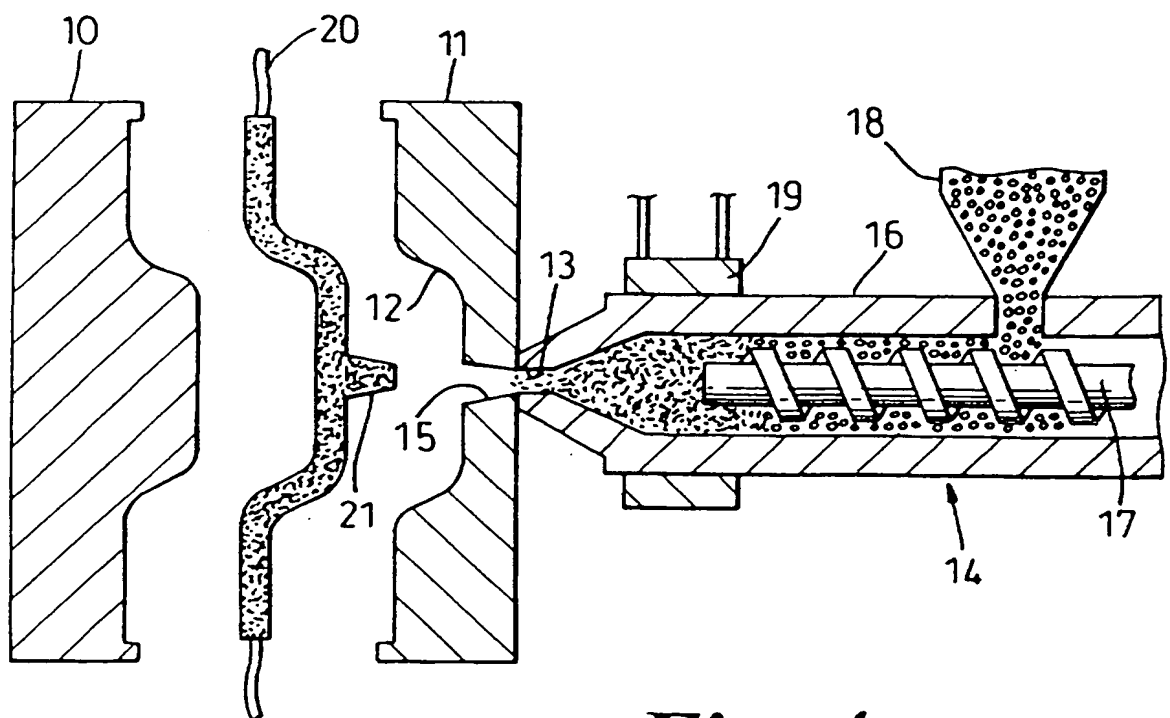


*Fig. 2*

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*Fig. 3*



*Fig. 4*

FIBRE REINFORCED THERMOPLASTIC ARTICLES

The invention relates to a method of forming fibre reinforced thermoplastic articles and to articles made by such a method.

It is well known to produce thermoplastic articles such as parts for a motor vehicle by injection moulding. However, widespread use of thermoplastic articles in that way has been restricted by their limited mechanical properties and in particular their limited structural rigidity. These limitations can be reduced by reinforcing such mouldings by adding glass fibre into the molten thermoplastic prior to injection in the conventional manner. However, during the injection of the mixed thermoplastic and glass fibre into the mould, the glass fibres tend to break into short lengths. This limits the improvement in the mechanical properties and in particular the rigidity that can be achieved.

GB 2 229 392 A discloses one method of overcoming the problems associated with such a pre-mix method. The document discloses the steps of placing a preform of relatively long reinforcing fibres into the cavity of a mould and then injecting the thermoplastic material into the cavity to encapsulate the preform.

However, when using such a method it is difficult to ensure that the molten thermoplastic material penetrates and wets the fibre preform. If the

fibre preform is not thoroughly wetted the thermoplastic article produced may not have the desired structural properties.

Glass fibre cloth containing glass fibres coated with polypropylene are known in the art. Conventionally such materials are heated and pressed  
5 into the shape of the moulded article to be desired. However, it is found that the polypropylene tends to shrink, resulting in a deformation of the glass fibres within the cloth and reducing their reinforcing effect.

An object of the invention is to provide an improved method of forming a fibre reinforced thermoplastic article which reduces the foregoing  
10 problems.

According to a first aspect of the invention there is provided a method of forming a fibre reinforced thermoplastic article comprising the steps of:

- (i) providing a cloth having incorporated therein a thermoplastic material and a fibrous material;
- 15 (ii) placing the cloth within a mould of desired shape and configuration of the article to be formed;
- (iii) filling the mould with a molten thermoplastic material which heats and melts the thermoplastic material incorporated in the cloth; and
- (iv) removing the article from the mould.

With such a method the problems of polypropylene shrinkage and deformation of the fibre in such cloth may be overcome by using the molten thermoplastic to heat and melt the polypropylene thermoplastic material incorporated in the cloth. The pressure of the molten thermoplastic also  
5 holds the cloth under pressure while the thermoplastic material incorporated in the cloth melts and consolidates, thus minimising shrinkage. The final product contains thoroughly wetted fibres embedded within a thermoplastic matrix with improved structural properties especially improved strength.

10 The thermoplastic material incorporated in the cloth may be the same material as the injected thermoplastic material. However, if the two thermoplastic materials are different, the two materials should be compatible with one another. For example, if polypropylene is incorporated in the cloth, it is preferred that the injected thermoplastic material is a  
15 polyamide-polypropylene alloy, or a compatibilised polyamide. The materials used for one or both of the thermoplastic materials preferably include polypropylene, polyamide, polyamide-polypropylene alloys, compatibilised polyamide or compatibilised polypropylene. Suitable compatibilisers for compatibilising polyamide or polypropylene are well  
20 known in the art.

In order to produce a good finish to the article, the method according to the invention may include a further step of lining at least part of the mould cavity with a film of a polymeric material prior to the placement of the cloth in the mould. Preferably the film is a pre-painted thermoplastic material  
5 such a polypropylene. Preferably at least the injected thermoplastic material is compatible with the polymeric material.

Preferably the moulding apparatus used is an injection moulding device of the type known in the art.

The cloth may be woven or non-woven. If the cloth is woven it may  
10 comprise strands or fibres of the fibrous material interwoven with strands or fibres of the first thermoplastic material. Alternatively or additionally the fibrous material may comprises fibres coated with the thermoplastic material by, for example, dref spinning.

Any suitable reinforcing fibrous material may be used. Preferred  
15 materials include glass fibres and mineral wool fibres.

A second aspect of the invention provides articles made by the method according the first aspect of the invention.

A method and an article in accordance with the invention will now be described by way of example only with reference to the accompanying drawings in which:-

Fig 1 shows a schematic cross-section through a dref spun fibre used to  
5 form the cloth used in the method according to the invention;

Fig 2 shows a schematic cross-section through a screw type injection moulded machine suitable for use in the method according to the invention, with the placement of a piece of cloth in the mould cavity;

Fig 3 shows a cross-section similar to Fig 2, showing the filling of a  
10 mould cavity according to the first aspect of the invention; and

Fig 4 is a cross-section similar to Fig 2 showing the removal of the finished article from the mould cavity according to the first aspect of the invention.

The invention uses cloth incorporating thermoplastic material and a  
15 fibrous material. Fig 1 shows a schematic cross-section through an example of a fibre used to make the cloth. The fibre 1 is formed of dref spun fibrous material, such as a glass fibre or a mineral wool fibre 2 coated with a thermoplastic material 3 such as polypropylene. Such fibres may be woven into cloth or, alternatively, may be in the form of a non-woven cloth such as  
20 a felt.



Cloth may also be formed of separate strands or fibres of the fibrous material interwoven with fibres or strands of the thermoplastic material. Alternatively a woven or non-woven cloth of fibrous material may be coated with the thermoplastic material, e.g. by dipping or spraying with the molten  
5 thermoplastic material or if appropriate with the thermoplastic material carried in a solvent.

Fig 2 shows a two part mould 10, 11 having a cavity 12 of a shape and configuration corresponding to the required shape and configuration of an article to be formed therein. A tapered passageway 15 connects the cavity  
10 12 to the outlet 13 of a high pressure injection moulding apparatus 14 of known kind.

The high pressure injection apparatus 14 comprises a barrel 16 supporting a screw 17, a hopper 18 and a heater 19. The hopper 18 is arranged to supply thermoplastic granules to the barrel 16. The heater 19  
15 encircles the end of the barrel nearest to the mould 11 and is arranged to heat the thermoplastic granules to a temperature where they become molten.

The method of producing an article is as follows:-

A piece of cloth 20 formed as described above is cut to shape and is placed into the mould cavity 12. The mould 10, 11 is then closed and held in the closed position by the application of a clamping force by means not shown in the figures. The cloth 20 may be slightly larger than the mould  
5 10, 12 so as to and overlap at least some of the edges of the mould. The clamping of the mould then has the effect of retaining the cloth 20 in position. This helps to prevent deformation of the cloth 20 when the thermoplastic material incorporated in the cloth 20 melts, as will be described below.

10 As shown in Fig 3, molten thermoplastic material such as polypropylene or polyamide/polypropylene alloy is injected into the cavity 12 through the tapered passageway 15 by the high pressure injection apparatus 14. The molten thermoplastic material pushes the cloth 20 against the mould 10, holding the fibres within the cloth in place whilst the  
15 polypropylene incorporated in the cloth is melted by the heat from the molten thermoplastic material.

When the cavity 12 is full of the molten thermoplastic material, the injection process is halted and the material is allowed to cool for a period sufficient to allow it to solidify. The mould 10, 11 is then opened to enable  
20 the article to be removed from the cavity 12 as shown in Fig 4. The finished article includes a sprue 21 resulting from the tapered passageway 15 which

connects the cavity 12 to the outlet 13 on the high pressure injection apparatus 14. The free ends of the cloth 20 and the sprue 21 are removed by cutting.

A film 22 of thermoplastic material such as polypropylene may be  
5 placed in the mould on one or both sides of the mould 10, 11 as shown in broken lines in Fig.2. The moulded article is made according to the method described above, the heat of the molten material from the high pressure injection apparatus 14 melting the interface between the article and the  
10 film 22 to produce an article with an improved finish. The pressure of the molten thermoplastic material from the high pressure injection apparatus 14 against the cloth 20 ensures that good adhesion is obtained between the film 22 and the rest of the article. The film 22 may be pre-painted with a thermoplastics or thermosetting polymer paint.

The film 22 helps to insulate the incoming molten thermoplastics  
15 material from the cooling effect of the surfaces of the mould cavity 12 and so promotes penetration of the cloth 20 and the melting of thermoplastic in the cloth. If necessary the mould 10, 11 can be heated or its cooling controlled to ensure that such penetration of the cloth 20 and melting of the thermoplastics can be achieved after a few injection cycles and without  
20 undue extension of the process cycle time caused by the time needed for the moulded component to solidify before removal from the mould.

CLAIMS

1. A method of forming a fibre reinforced thermoplastic article comprising the steps of;
  - (i) providing a cloth having incorporated therein a thermoplastic material and a fibrous material;
  - (ii) placing the cloth within a mould of desired shape and configuration of the article to be formed;
  - (iii) filling the mould with a molten thermoplastic material which heats and melts the thermoplastic material incorporated in the cloth; and
  - (iv) removing the article from the mould.
2. A method of forming a fibre reinforced article according to claim 1, wherein the cloth is woven.
3. A method of forming a fibre reinforced article according to claim 2, wherein the cloth comprises strands or fibres of the fibrous material interwoven with strands of the incorporated thermoplastic material.
4. A method of forming a fibre reinforced article according to claim 1 or 2 wherein the fibrous material comprises fibres coated with the incorporated thermoplastic material.

5. A method of forming a fibre reinforced article according to any previous claim wherein the fibrous material comprises glass fibres or mineral wool fibres.
6. A method of forming a fibre reinforced article according to any previous claim wherein the thermoplastic incorporated in the cloth material is the same material as the injected thermoplastic material.
7. A method of forming a fibre reinforced article according to any previous claim wherein the thermoplastic material incorporated in the cloth is polypropylene, polyamide, a polyamide-polypropylene alloy, a compatibilised polyamide or a compatibilised polypropylene.
8. A method of forming a fibre reinforced article according to any previous claim wherein the injected thermoplastic material is polypropylene, polyamide, a polyamide-polypropylene alloy, a compatibilised polyamide or a compatibilised polypropylene.
9. A method of forming a fibre reinforced article according to any previous claim in which the method includes the further step of lining at least part of the mould cavity with a film of a polymeric material prior to the placement of the cloth in the mould.

10. A method of forming a fibre reinforced article according to claim 9, wherein the film is a pre-painted thermoplastic material.
11. A method of forming a fibre reinforced article according to claim 10 wherein the pre-painted thermoplastic material is polypropylene.
12. A method of forming a fibre reinforced article substantially as hereinbefore described with reference to the accompanying figures.
13. An article made by a method according to any previous claim.